(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 871 238 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
14.10.1998 Bulletin 1998/42

(51) Int Cl.6: H01Q 9/04

(21) Application number: 98660023.7

(22) Date of filing: 24.03.1998

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 25.03.1997 FI 971235

(71) Applicant: NOKIA MOBILE PHONES LTD.
02150 Espoo (FI)

(72) Inventors:
- Ollikainen, Jani
Otakaari 5 A, 02150 Espoo (FI)
- Vianikainen, Pertti
Otakaari 5 A, 02150 Espoo (FI)

(74) Representative: Levlin, Jan Markus
Berggren Oy Ab
P.O. Box 16
00101 Helsinki (FI)

(54) **Broadband antenna realized with shorted microstrips**

(57) The invention relates to antenna structures, particularly to substantially planar broadband antennas realised by microstrips. The antenna structure according to the invention has at least two superimposed strips (10, 20), which have a length of about a quarter-wave and which at one end are short circuited to the ground plane (30). The strips (10, 20) have certain resonance frequencies, which are tuned close to each other so that the operating band of the antenna structure is substantially continuous.

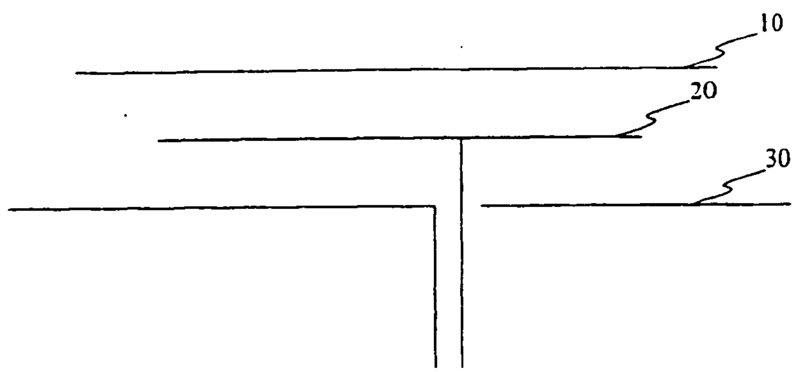

Fig. 1a

EP 0 871 238 A2

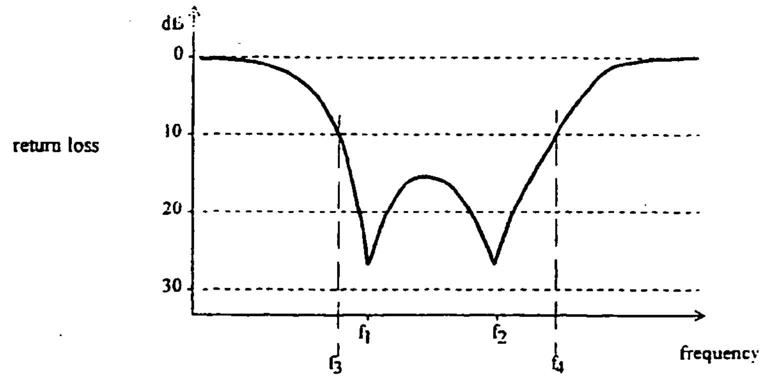

Fig. 1b

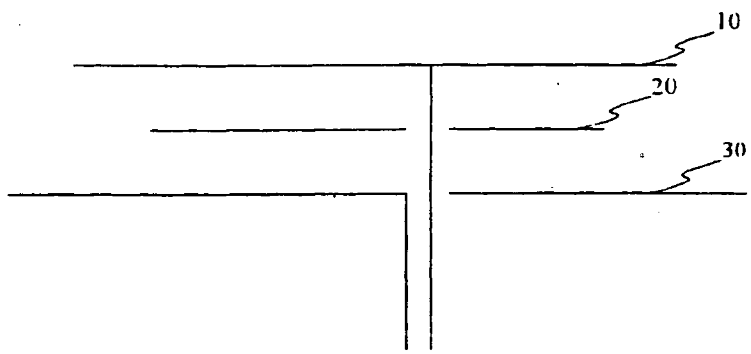

Fig. 1c

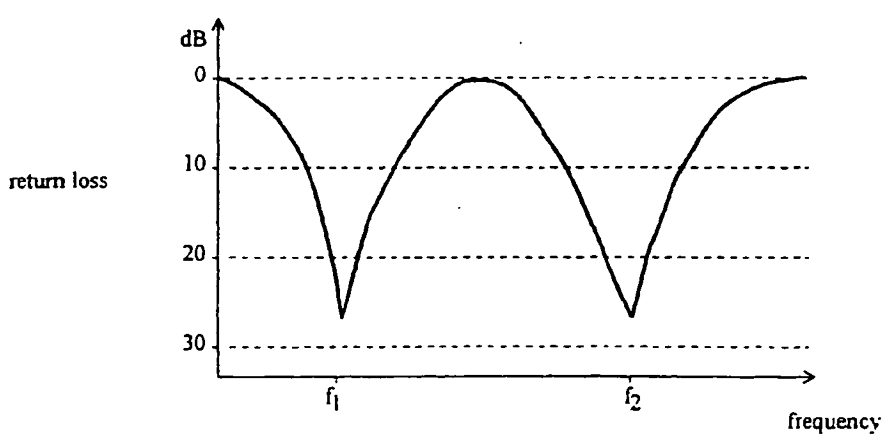

Fig. 1d

Description

The invention relates to antenna structures and more particularly to broadband antennas realised with microstrips.

A conventional microstrip antenna comprises a ground plane and a radiator isolated from the ground plane by a dielectric layer. The resonance frequency of the microstrip antenna is determined by the dimensions of the radiator and the distances between the radiator and the ground plane.

Further there are such known microstrip antenna structures where one edge of the radiator is shorted to the ground plane. In this arrangement a certain resonance frequency is obtained with significantly smaller physical dimensions than in the above described simple microstrip antenna.

However, a problem of the prior art structures is that they are thick and have a narrow bandwidth. The antennas used in personal mobile stations must have a small size. However, when a microstrip antenna is made thinner its useful bandwidth is reduced. Many mobile stations require a relatively wide frequency band, e.g. in the DCS-1800 system a relative frequency band which is about 10 % of the centre frequency. With prior art microstrip antenna structures it is not possible to realise an antenna which at the same time is thin enough and has a sufficiently wide bandwidth. Different microstrip antenna structures are described for instance in the books "Handbook of Microstrip Antennas", J R. James and P.S. Hall (Eds), Vol. 1, Peter Peregrinus Ltd, London 1989; and "Analysis, Design and Measurement of Small and Low-Profile Antennas", K. Hirasawa and M. Haneishi, Artech House, Boston 1992.

Figure 1a shows a microstrip antenna structure described in the above mentioned book "Handbook of Microstrip Antennas", whereby the structure comprises two radiating strips 10, 20 and a ground plane 30. Power is fed into the lower strip 20, whereby the upper strip operates as a parasitic radiator. The resonance frequencies of the strips 10, 20 are tuned to be slightly different, whereby the relatively weak coupling between the strips 10, 20 results in a high return loss for the antenna structure, also in the band between the resonance frequencies of the strips, whereby the antenna operates effectively on a continuous wide frequency band. This fact is illustrated in figure 1b, which shows an example of the return loss of a antenna structure of this type. Figure 1b shows the resonance frequencies f_1 and f_2 of the strips 10, 20, and the frequency boundaries f3 and f4 for a return loss of over 10 dB, which define the useful frequency band of said antenna structure.

The disadvantage of such a structure is its thickness it is not possible to realise an antenna structure according to figure 1a which is arbitrary thin, because when the distance between the strips is reduced their mutual coupling is increased, whereby the resonance frequencies of the strips are drawn farther apart and the broadband function is lost. The same book also presents a double-band microstrip antenna, which is shown in figure 1c. In this structure the power is supplied to the upper strip 10. In a structure of this kind there is a strong coupling between the strips 10, 20 via the line feeding the antenna, whereby the strips 10, 20 have different resonance frequencies. Thus an antenna structure of this kind has two different narrow operating bands.

If the coupling is too strong, then the resonance frequencies f_1 and f_2 will move so far apart that the antenna structure will not have a wide operating band. This situation is illustrated in figure 1d, where it is seen that in this case the useful frequency band of the antenna structure is not continuous, but this represents an antenna resonating at two different operating frequencies.

The US patent publication 5,124,733 (Haneishi) presents an antenna structure according to figure 2, which combines the open microstrip antenna structure with two operating bands presented in figure 1c, with a quarter-wave microstrip structure, which results in a small-sized microstrip antenna with two bands. In this structure the strips 10, 20 of one end of the respective strip are shorted to the ground plane 30. Because said patent publication presents a double-band antenna structure, the stronger coupling between the strips caused by the shorted strips does not hamper the operation of the antenna, as the antenna operates on two frequency bands already due to the strong coupling between the strips caused by the feeding to the upper strip 10. However, said publication does not present a broadband antenna structure.

The object of the invention is to realise a small-sized, broadband, planar antenna applicable in a personal mobile station. An object of the invention is also to realise a broadband microstrip antenna which is as thin as possible. A further object of the invention is to realise a structure which meets the above requirements and which further is well suited for serial production.

The objects are attained by realising an antenna structure having at least two superimposed short-circuited microstrips with a length of about one quarter-wave, by tuning the resonance frequencies of the strips to be slightly different, by arranging the antenna feed to the lower strip, and by arranging the coupling between the strips to be sufficiently weak, whereby the resonance frequencies of the strips form a continuous operating band.

The microstrip antenna according to the invention is characterised in that which is stated in the characterizing portion of the independent claim directed to a microstrip antenna. The mobile station according to the invention is characterised in that which is stated in the characterizing portion of the independent claim directed to a mobile station. The dependent claims describe further advantageous embodiments of the invention.

The invention is described in more detail below with reference to preferred embodiments presented as ex-

amples, and to the enclosed figures, in which:

figure 1a shows a prior art open microstrip antenna structure;

figure 1b shows the return loss as a function of frequency in the structure according to figure 1a;

figure 1c shows another prior art open microstrip antenna structure;

figure 1d shows the return loss as a function of frequency in the structure according to figure 1c;

figure 2 shows a prior art antenna formed by short circuited microstrips and having two bands;

figure 3 shows the basic structure of a preferred embodiment of the invention;

figure 4 shows the design of the strips in a preferred embodiment of the invention;

figure 5a shows the structure of a preferred embodiment of the invention in which the second strip is divided into two sections;

figure 5b shows another structure of a preferred embodiment of the invention in which the second strip is divided into two sections;

figure 5c shows a possible way in which the radiating strip of the antenna structure according to the invention is divided into sections;

figure 5d shows another possible way in which the radiating strip of the antenna structure according to the invention is divided into sections;

figure 6 shows a preferred way to realise the short circuiting member 110;

figure 7 shows another preferred way to realise the short circuiting member 110;

figure 8 shows a third preferred way to realise the short circuiting member 110; and

figure 9 shows as an example an object in which the antenna according to the invention is applied.

The same reference numerals and markings are used to identify like parts.

The figures 1a, 1b, 1c, 1d and 2 were described above when the prior art was described. Figure 3 presents the basic structure of a preferred embodiment of the invention. The antenna comprises a ground plane 30, a lower strip 20 and an upper strip 10. The strips 10, 20 are short circuited to the ground plane 30 by short circuiting member 110. The antenna feed is connected to the lower strip 20. The frequency response of an antenna structure of this kind depends on the dimensions of the elements in the antenna structure. Both strips 10, 20 have a certain resonance frequency which in the structure according to the invention are tuned slightly apart, whereby the antenna structure will have a wider useful frequency range.

In the antenna structure according to the invention the power is fed into the lower strip 20, and the upper strip operates as an electromagnetically coupled radiator. As a method to feed the antenna it is possible to use a pin feed realised e.g. by a coaxial cable or by other means, a feed realised by a microstrip, a hole-feed, a slotted line feed, a feed realised by a coplanar line, a proximity-coupled feed, or some other prior art feeding method commonly used in microstrip antennas. The antenna structure according to the invention can also have more than two strips 10, 20. In this kind of applications the antenna feed can be connected to any one of the radiating strips which are located between the ground plane and the upper radiator.

In the antenna structure according to the invention the strips 10, 20 can have the same width, or they can have different widths. In the antenna structure according to the invention the strips 10, 20 preferably have a length which is about one quarter-wave. The preferred length L of the strips 10, 20 can be approximated with the formula below:

$$L = \frac{\lambda_0}{4} - h$$

where h is the distance between the lower face of the strip and the upper face of the ground plane. It should be noted that this formula is applicable only for microstrip antennas with air dielectric, and the formula only approximates suitable lengths for the strips.

In addition to a rectangular design the strips 10, 20 of the antenna according to the invention can also have many different forms, for instance circular, triangular or pentagonal, according to the requirements of the application. It is also possible to bend the strips in many different ways, whereby for instance the distance between the lower strip and the ground plane can be larger in the open end than in the short circuited end.

In the antenna structure according to the invention the width of the strips 10, 20 can vary according to the requirements of the respective embodiment. The strips can have different widths. At the minimum end the strips can be threadlike, very close to a theoretically ideal one-dimensional, infinitely narrow element.

With the design of the strips it is possible to influence the coupling between the strips and thus the characteristics of the whole antenna structure. In an antenna structure according to the invention which has two strips

10, 20, the upper strip is preferably as wide as or narrower as the lower strip. When the upper strip is made wider it is possible to increase the coupling of the upper strip to the field between the lower strip and the ground plane. However, in an antenna structure according to the invention this coupling is relatively strong, due to the small distance between the strips, whereby there is no need to increase the coupling by making the upper strip wider than the lower strip.

With the size of the ground plane it is possible to have an influence on the radiation pattern of the antenna according to the invention. If the ground plane is larger than the radiator the antenna's radiation pattern is stronger in the direction opposite to the ground plane, but if the ground plane is substantially as large as the radiator, then the antenna has an equal radiation in both directions. The size of the ground plane also has an influence on the bandwidth: an increased size of the ground plane reduces the bandwidth.

The resonance frequency of any of the strips or strip sections in the antenna structure of the invention can be controlled by their dimensioning and also with parasitic strips which are adjacent to the strip or strip section and lie in the same plane.

In a preferred embodiment of the invention the strips 10, 20 have gaps, which reduce the physical size of the strips. Figure 4 shows one possible structure of the strip 10, 20 of this embodiment. In this embodiment the strip can have one or more gaps 200 and indents 210, as shown in figure 4 The effect of a gap 200 or indent 210 is based on the fact that due to the gap or indent the current flowing in the strip must travel a longer way than in a corresponding strip without indents, whereby the electrical length of the strip increases. Thus the gaps 200 and indents 210 act as means which increase the inductance.

Figure 5a shows a preferred embodiment of the invention where the upper strip is 10 divided into two sections. In this embodiment the strip sections 11 can be tuned to slightly different resonance frequencies. which results in an increased number of resonance peaks in the resonance band of the total antenna structure, which thus increases the bandwidth of the total antenna structure. For instance, if the upper strip is divided into two sections and the sections are tuned to different frequencies by changing their length, then the antenna will be a broadband antenna with three resonators. The upper strip could also be divided into more than two sections.

In an embodiment like this the distance between the strip sections 11 must be larger than a certain limit: if the distance between the strips is very small, then their electromagnetic coupling is so strong that the strip sections act as one undivided strip.

In another preferred embodiment of the invention the bandwidth of the antenna structure is made wider by dividing also the lower strip into more than one section. In an embodiment of this kind it is possible to feed the power into one ore more strip sections

Figure 5b shows a preferred embodiment of the invention similar to that of figure 5a, but where the upper strip sections 11 and the lower strip 20 have a common short circuiting plate 110.

Figure 5c shows a possible way to divide a strip 10, 20 in an antenna structure according to the invention. The width of the strip sections 11 can vary also within the same strip. It is also possible to make projections 12 in the strips with which it is possible to influence the coupling between the strip sections.

Figure 5d shows another possible way to divide a strip 10, 20 in an antenna structure according to the invention. The strip sections can also be connected by one or more narrow joining strips 13. In this embodiment it is possible to have an influence on the coupling between the strip sections by selecting the position and the width of the joining strip 13, by selecting the number of joining strips 13, and by varying the distance between the strip sections 11 connected by a joining strip 13.

In figures 5c and 5d the strip sections can be strip sections which result from a division of any of the strips 10, 20.

In the antenna structure according to the invention the grounding of the radiators can be realised in many different ways. Figure 3 shows a preferred embodiment of the invention, in which the radiators 10, 20 are connected to the ground plane 30 by an electrically conducting plate 110 connected to one edge of the radiator 10, 20. In the embodiment of figure 3 both strips 10, 20 are grounded by an own electrically conducting plate 110. In the antenna structure according to the invention these plates can be interconnected through the ground plane 30 and in addition also by a separate electrically conducting member, or the plates can partly contact each other. In the antenna structure according to the invention the grounding can also be common, whereby there is only one electrically conducting plate 110, to which all strips are fastened.

Another preferred way to ground the strips, i.e. using through coppered holes, can be used particularly in an embodiment in which there is a dielectric insulating layer between the strips. Figure 6 shows a preferred embodiment of the invention, in which the strips 10, 20 are connected to the ground plane 30 by using through coppered holes 100. Figure 6 shows this structure in a top view and as a section along the line A - B. In the embodiment of figure 6 the strips 10, 20 are connected separately to the ground plane. In this embodiment the through coppered holes 100 of the upper strip 10 do not have a galvanic connection to the lower strip 20.

Figure 7 shows another preferred embodiment of the invention, in which the connection of the strips 10, 20 to the ground plane 30 is realised by through coppered holes 100. Figure 7 shows this structure in a top view and as a section along the line A - B. In the embodiment of figure 7 the strips 10, 20 are jointly connected to the ground plane, whereby the through coppered holes 100 form the contact both to the upper strip 10

and to the lower strip 20.

To a person skilled in the art it is obvious that the number of the holes 100 can vary according to the requirements of the respective embodiment, and that in addition to the coppered holes the electrically conducting connection of the holes 100 can be realised also in some other known manner, such as with a short circuiting pin or a lead-through sleeve.

It is preferable to use through coppered holes 100 or corresponding lead-throughs as short circuiting members, because with them it is possible to influence the inductance of the short circuit in the same way as the gaps 200 can have an influence on the inductance of the strips. The strips 10, 20 can be made shorter, retaining the same resonance frequency, by reducing the number of the through coppered holes, as this increases the inductance of the short circuit. However, an increased inductance may reduce the bandwidth of the antenna.

The inductance of the short circuiting members 110 can also be increased in other ways. For instance, the strips 10, 20 of the antenna structure shown in figure 1 can be made shorter by adding gaps 200 or other means for increasing the inductance to the short circuiting members 110, for instance in the manner shown in figure 8.

The figures of this application present such illustrative embodiments of the invention in which the short circuiting plate 110 is perpendicular to the strip 10, 20. However, the invention is not limited to these examples, but the angle between the short circuiting plate 110 and the strip 10, 20 can also be any other angle than a right angle. The short circuiting member can also be formed by bending one end of the strip 10, 20 into an arcuate form and by fastening this bent end to the ground plane 30, whereby there is no angle between the short circuiting member formed in this manner and the radiating part of the strip.

In the antenna structure according to the invention the dielectric between the radiators 10, 20 and the dielectric between the lower radiator 20 and the ground plane can advantageously be some low loss microstrip substrate material known by a person skilled in the art, e.g. a suitable printed board material. Also air can act as the dielectric material. For example, the antenna may be realised with at least two stacked printed boards, each having at least one electrically conducting layer with patterns forming the antenna elements on the surfaces of the boards, or with a single multilayer board having conductive elements formed in the various layers of the multilayer board for realising at least the ground plane and the strips of the antenna. In these examples, the short circuiting members can advantageously be realised with electrically conducting lead-throughs formed in the board or boards.

The antenna structure according to the invention provides a wide frequency response ; with one antenna structure according to the invention we measured for the 10 dB return loss a bandwidth, which was even 14 % of the centre frequency, which is more than twice the value compared to the bandwidth of a prior art microstrip antenna with a corresponding thickness.

With the antenna structure according to the invention it is possible to realise thinner microstrip antennas than in prior art, and still obtain a wide useful antenna bandwidth, which is required for instance in mobile stations of the DCS-1800 system.

Figure 9 shows as an example an object in which the antenna according to the invention is advantageously applied, i.e. a mobile station. According to figure 9 the antenna structure according to the invention can be located inside the cover of the mobile station 1, whereby it is protected from shocks and blows directed against the mobile station. This is a significant advantage compared to conventional whip antennas, because the whip antennas used in conventional mobile stations are easily bent or broken, if the user inadvertently drops the mobile station.

The broadband antenna according to the invention can also be utilised in almost any other prior art radio application requiring a small-sized antenna, such as in a base station of a wireless office system. A thin planar antenna can be located for instance in the same box as the other components of the base station, whereby it is simple to install a base station of this kind on the wall in an office corridor, for instance, without a separately installed antenna. An embodiment of this kind can advantageously use the directivity of the antenna structure according to the invention: when the ground plane 30 is made slightly larger than the other strips 10, 20, the radiation pattern of the antenna can be emphasised to lie more on the same side of the ground plane as the strips 10, 20. This provides the advantage that the radiation power of the antenna is then stronger in the desired space, and radiation power is not lost in the mounting surface of the base station, for instance.

In this application the term "microstrip antenna" also relates to air-dielectric self-supporting structures, in addition to microstrip antennas realised on different substrates.

To a person skilled in the art it is obvious that the above described embodiments can be combined in many different ways in different applications of the antenna structure according to the invention. Above the invention was described with reference to some of its advantageous embodiments, but it is obvious that the invention can be modified in many different ways within the inventive idea defined in the enclosed claims.

Claims

1. A microstrip antenna comprising a ground plane (30), a first strip (10) and a second strip (20) arranged between the ground plane and the first strip, **characterised** in that it further comprises

- first and second short circuiting members (110), whereby one end of the first strip is short circuited to the ground plane by the first short circuiting member and the corresponding end of the second strip is short circuited to the ground plane by the second short circuiting member,
- and in that the first strip has a first resonance frequency and the second strip has a second resonance frequency, whereby the first and the second resonance frequencies form a substantially continuous operating band,
- and in that the microstrip antenna feed is arranged at the second strip (20), and in that at least one of said strips (10, 20) contains means (200, 210) which increase the inductance.

2. A microstrip antenna according to claim-1, **characterised** in that at least one of said strips (10, 20) is divided into at least two sections (11).

3. A microstrip antenna according to claim 2, **characterised** in that said at least two sections (11) are interconnected by an electrically conducting connection (13).

4. A microstrip antenna according to claim 2, **characterised** in that said first and second short circuiting members (110) are at least partly interconnected.

5. A microstrip antenna according to claim 1, **characterised** in that at least one of said short circuiting members contains means (200) which increase the inductance.

6. A microstrip antenna according to claim 1, **characterised** in that the strips (10, 20) are formed on surfaces of at least one microstrip substrate, and that said short circuiting members are realised by electrically conducting lead-throughs formed in said at least one substrate.

7. A mobile station (1), **characterised** in that the antenna of the mobile station is a microstrip antenna comprising a ground plane (30), a first strip (10) and a second strip (20) arranged between the ground plane and the first strip, and first and second short circuiting members (110), whereby one end of the first strip is short circuited to the ground plane by the first short circuiting member and the corresponding end of the second strip is short circuited to the ground plane by the second short circuiting member,

   - and in that the first strip has a first resonance frequency and the second strip has a second resonance frequency, whereby the first and the second resonance frequencies form a substantially continuous operating band,
   - and in that the microstrip antenna feed is arranged at the second strip (20),
   - and in that the microstrip antenna feed is arranged at the second strip (20), and that at least one of said strips (10, 20) contains means (200, 210) which increase the inductance.

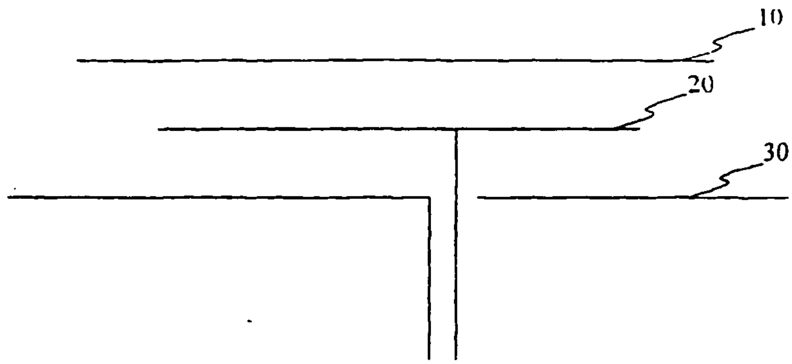

Fig. 1a

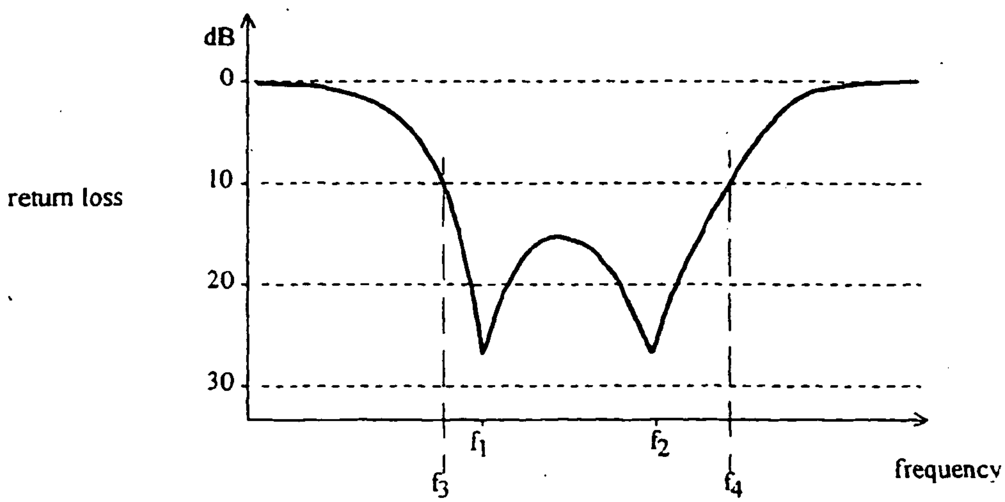

Fig. 1b

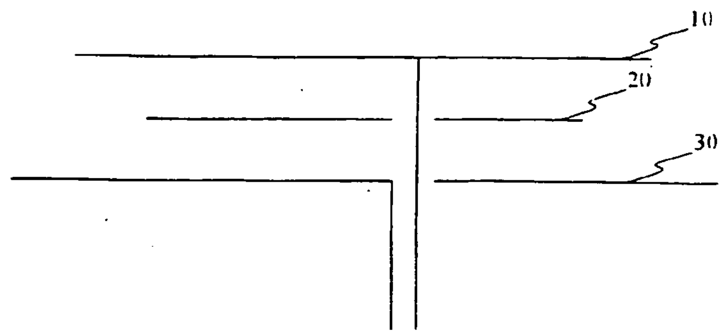

Fig. 1c

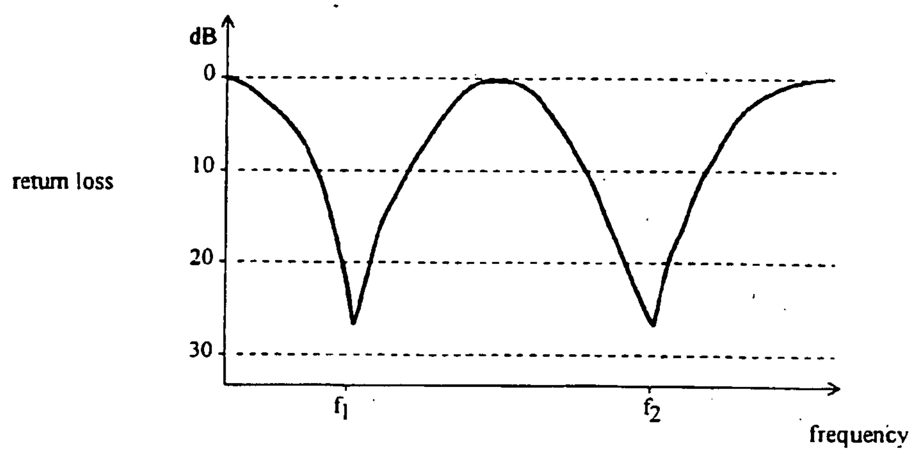

Fig. 1d

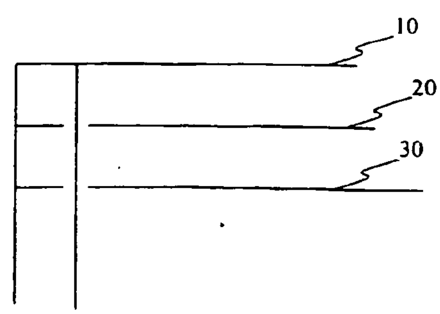

Fig. 2

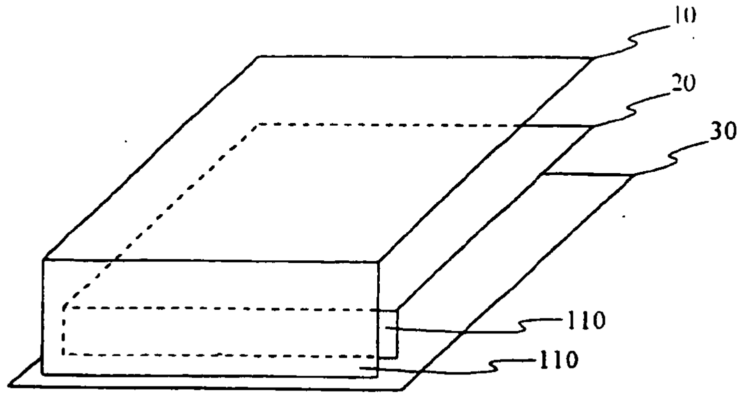

Fig. 3

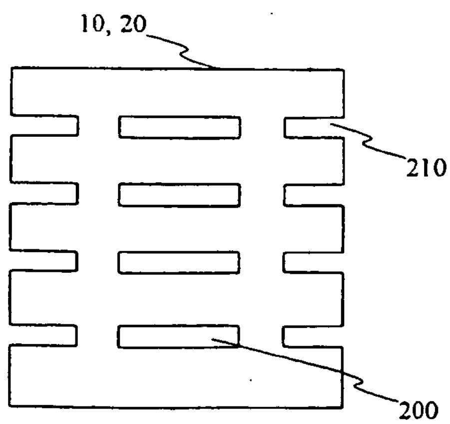

Fig. 4

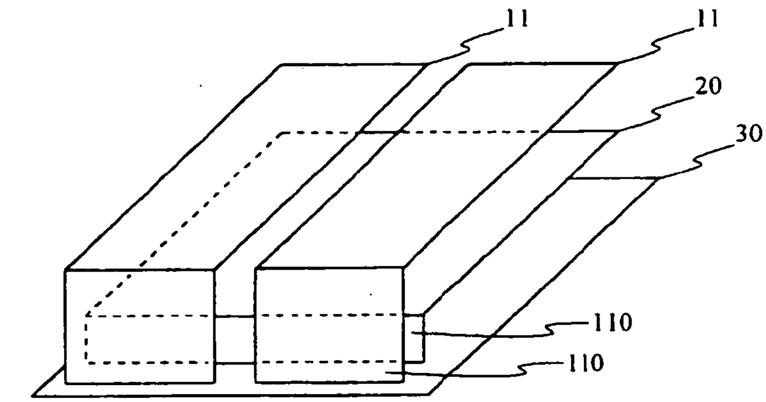

Fig. 5a

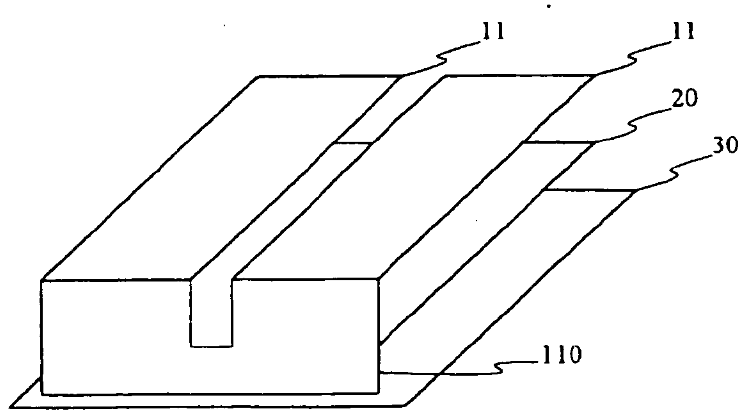

Fig. 5b

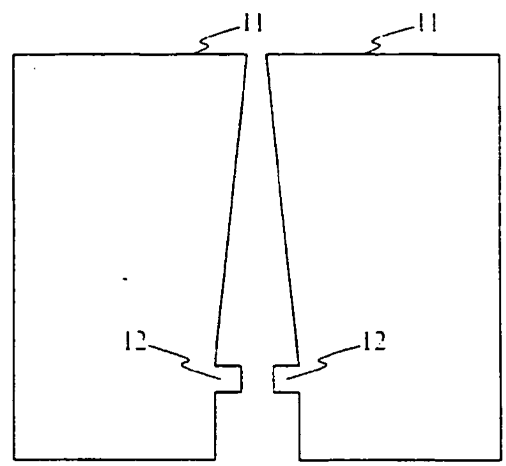

Fig. 5c

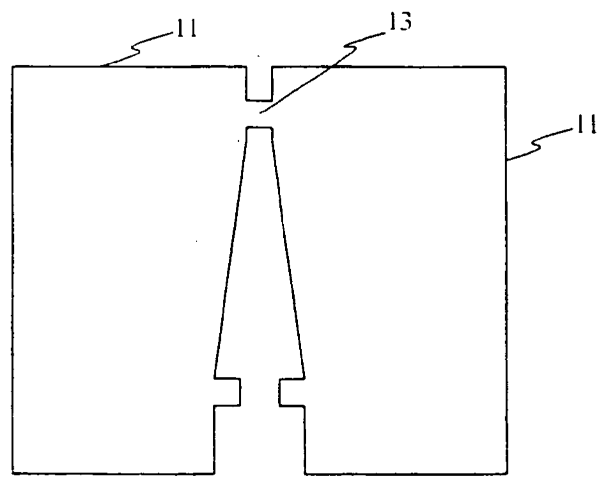

Fig. 5d

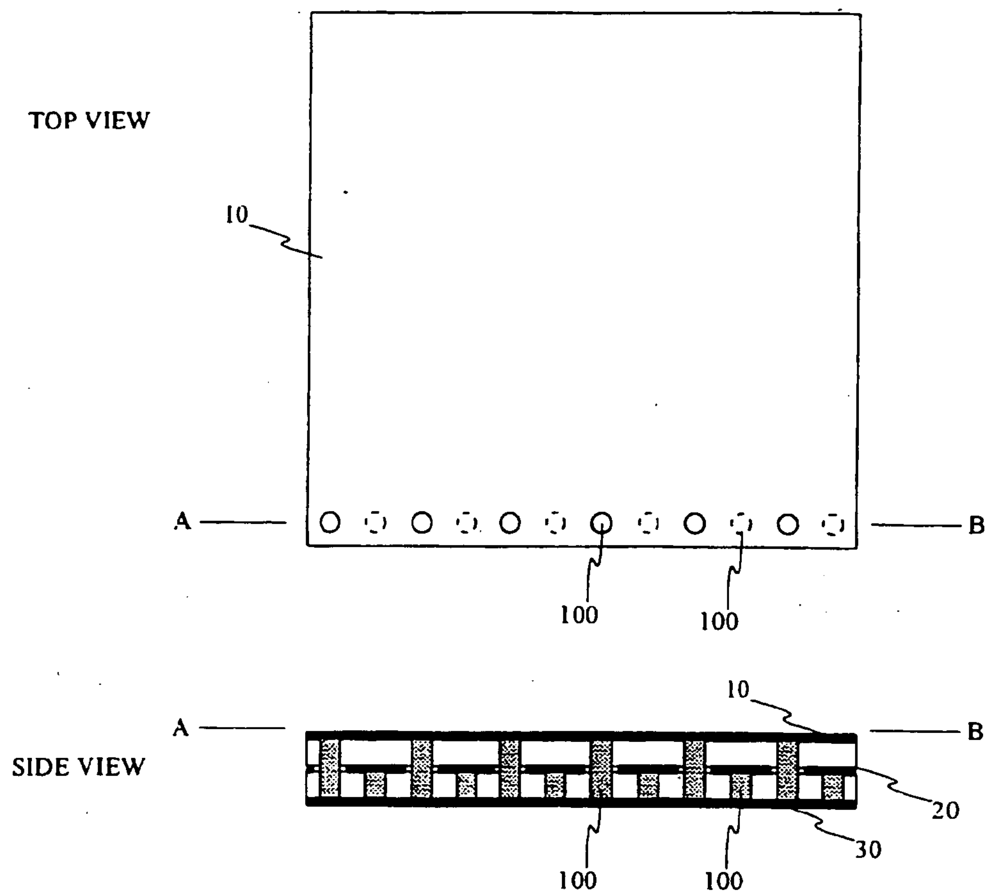

Fig. 6

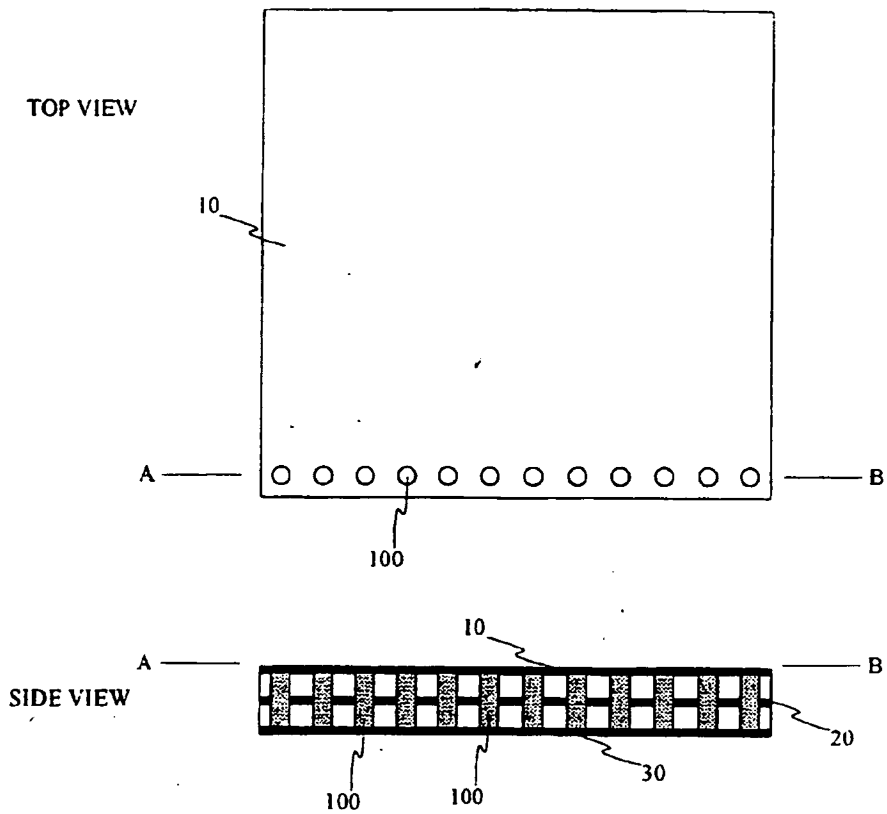
TOP VIEW
10
A
B
100
10
A
B
SIDE VIEW
20
30
100
100

Fig. 7

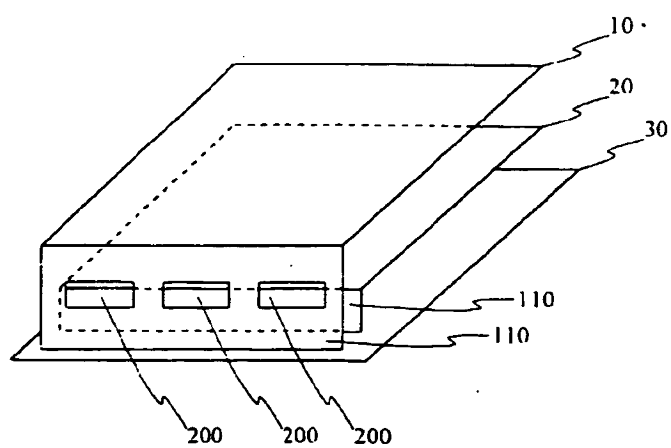
10
20
30
110
110
200
200
200

Fig. 8

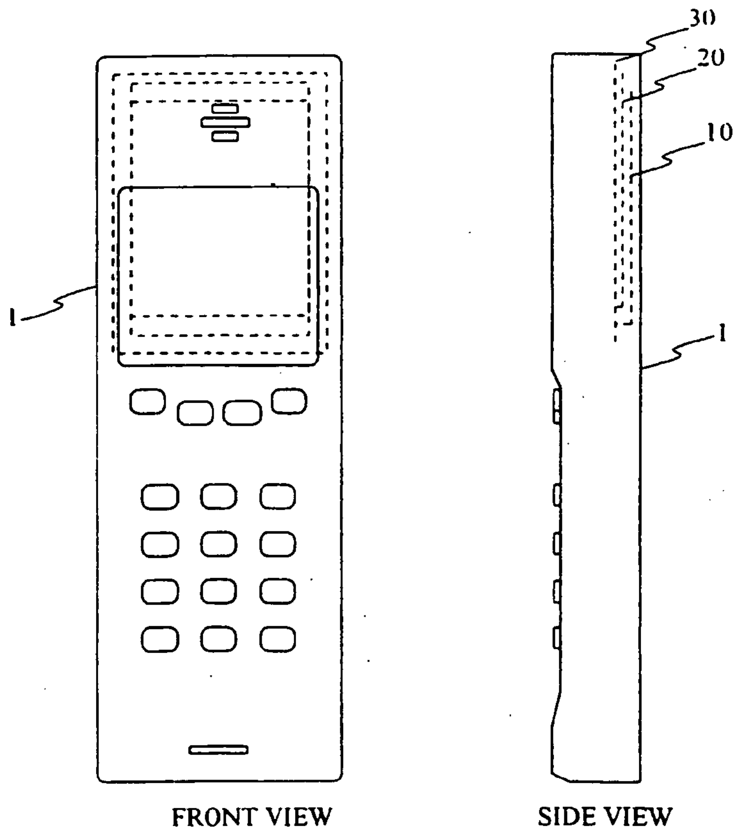

Fig. 9

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 871 238 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
26.05.1999 Bulletin 1999/21

(51) Int Cl.[6]: H01Q 9/04

(43) Date of publication A2:
14.10.1998 Bulletin 1998/42

(21) Application number: 98660023.7

(22) Date of filing: 24.03.1998

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 25.03.1997 FI 971235

(71) Applicant: NOKIA MOBILE PHONES LTD.
02150 Espoo (FI)

(72) Inventors:
- Ollikainen, Jani
  Otakaari 5 A, 02150 Espoo (FI)
- Vainikainen, Pertti
  Otakaari 5 A, 02150 Espoo (FI)

(74) Representative: Levlin, Jan Markus
Berggren Oy Ab
P.O. Box 16
00101 Helsinki (FI)

(54) Broadband antenna realized with shorted microstrips

(57) The invention relates to antenna structures, particularly to substantially planar broadband antennas realised by microstrips. The antenna structure according to the invention has at least two superimposed strips (10, 20), which have a length of about a quarter-wave and which at one end are short circuited to the ground plane (30). The strips (10, 20) have certain resonance frequencies, which are tuned close to each other so that the operating band of the antenna structure is substantially continuous.

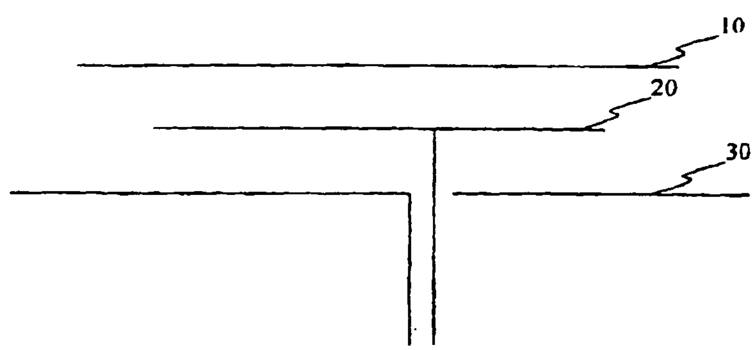

Fig. 1a

EP 0 871 238 A3

Printed by Jouve, 75001 PARIS (FR)

(Cont. next page)

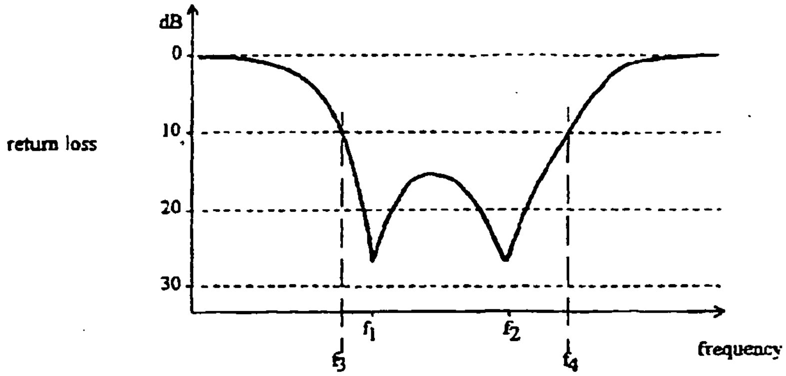

Fig. 1b

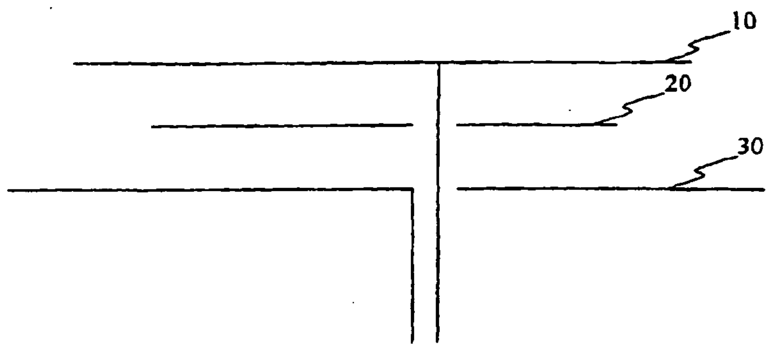

Fig. 1c

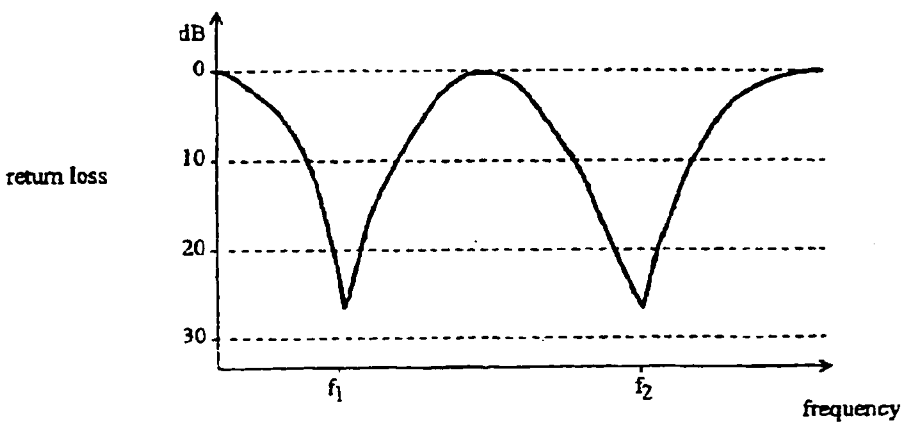

Fig. 1d

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 66 0023

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
D,Y	US 5 124 733 A (HANEISHI) 23 June 1992 * column 4, line 19 - line 33; figure 8 *	1	H01Q9/04
Y	DE 26 33 757 A (BALL CORP.) 14 April 1977 * page 16, line 6 - line 18; figure 4 *	1	
A	GB 2 147 744 A (ELECTRONIQUE SERGE DASSAULT) 15 May 1985 * abstract; figure 8 *	1	
A	EP 0 176 311 A (MATSUSHITA ELECTRIC INDUSTRIAL CO. LTD.) 2 April 1986 * page 12, line 22 - page 13, line 5; figures 1,5 *	6	
A	US 5 365 246 A (RASINGER ET AL.) 15 November 1994 * abstract; figure 7 *	1,7	
A	WO 96 27219 A (THE CHINESE UNIVERSITY OF HONG KONG) 6 September 1996 * page 5, line 24 - line 33; figures 2A,3A,4A *	1,7	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	31 March 1999	Danielidis, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 66 0023

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

31-03-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5124733 A	23-06-1992	JP 3263903 A	25-11-1991
DE 2633757 A	14-04-1977	US 4070676 A	24-01-1978
		CA 1067996 A	11-12-1979
		FR 2327650 A	06-05-1977
		GB 1526505 A	27-09-1978
		JP 1263539 C	16-05-1985
		JP 52046745 A	13-04-1977
		JP 59042484 B	15-10-1984
GB 2147744 A	15-05-1985	FR 2552938 A	05-04-1985
		DE 3436227 A	11-04-1985
EP 176311 A	02-04-1986	JP 1880934 C	21-10-1994
		JP 6001848 B	05-01-1994
		JP 61071701 A	12-04-1986
		DE 3584658 A	19-12-1991
		US 4700194 A	13-10-1987
US 5365246 A	15-11-1994	AT 393054 B	12-08-1991
		AT 112421 T	15-10-1994
		DE 59007355 D	03-11-1994
		WO 9102386 A	21-02-1991
		EP 0484454 A	13-05-1992
		JP 5500889 T	18-02-1993
WO 9627219 A	06-09-1996	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No 12/82